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## **Mitral annuloplasty in patients with ischemic versus dilated cardiomyopathy**

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**Abstract:** Objective: Mitral regurgitation is a frequent finding in patients with end-stage cardiomyopathy predicting poor survival. Conventional treatment consists medical treatment or cardiac transplantation. However, despite severely decreased left ventricular function, mitral annuloplasty may improve survival and reduce the need for allografts. Methods: From January 1996 to July 2002, 121 patients with severe end-stage dilated (DCM) or ischemic cardiomyopathy (ICM), mitral regurgitation 2, and left ventricular ejection fraction 30% underwent mitral valve annuloplasty using a flexible posterior ring. DCM was diagnosed in 30 patients (25%), whereas ICM was found in 91 patients (75%). Concomitant tricuspid valve repair was performed in 14 (46.6%) patients in the DCM, and in 11 (12%) in the ICM group ( $P=0.0001$ ), coronary artery bypass grafting in three (10%) in the DCM, and in 78 patients (86%) in the ICM group ( $P<0.00001$ ). The mean follow-up time was  $567\pm 74$  days in the DCM and  $793\pm 63$  days in the ICM group (ns). Results: Early mortality was 6.6% (8/121), and was equal for both groups. Improvement in NYHA class (DCM  $3.3\pm 0.1$ - $1.8\pm 0.16$ ; ICM from  $3.2\pm 0.04$  to  $1.7\pm 0.07$ ) were equal between groups after 1 year. Seventeen (15%) late deaths occurred during the follow-up period. There was no difference in the 2-year actuarial survival between groups (DCM/ICM 0.93/0.85). Risk factors for mitral reconstruction failure, defined as regurgitation 2 after 1 year, were preoperative NYHA IV in the DCM group ( $P=0.03$ ), a preoperative posterior infarction ( $P=0.025$ ), decreased left ventricular function ( $P=0.043$ ), larger ring size ( $P=0.026$ ) and preoperative renal failure ( $P=0.05$ ) in the ICM group. Risk factors for death were larger ring size ( $P=0.02$ ) and an increased LVEDD ( $P=0.027$ ) in the DCM group and the postoperative use of IABP ( $P=0.002$ ), renal failure ( $P=0.001$ ), and a larger preoperative LVESD ( $P=0.035$ ) in the ICM group. Conclusion: Mitral reconstruction with a posterior annuloplasty using a flexible ring is effective in patients with severely depressed left ventricle function and has an acceptable operative mortality. Mid-term results are superior to medical treatment alone and comparable to cardiac transplantation

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## Mitral annuloplasty in patients with ischemic versus dilated cardiomyopathy<sup>☆</sup>

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### Abstract

**Objective:** Mitral regurgitation is a frequent finding in patients with end-stage cardiomyopathy predicting poor survival. Conventional treatment consists medical treatment or cardiac transplantation. However, despite severely decreased left ventricular function, mitral annuloplasty may improve survival and reduce the need for allografts. **Methods:** From January 1996 to July 2002, 121 patients with severe end-stage dilated (DCM) or ischemic cardiomyopathy (ICM), mitral regurgitation  $\geq 2$ , and left ventricular ejection fraction  $\leq 30\%$  underwent mitral valve annuloplasty using a flexible posterior ring. DCM was diagnosed in 30 patients (25%), whereas ICM was found in 91 patients (75%). Concomitant tricuspid valve repair was performed in 14 (46.6%) patients in the DCM, and in 11 (12%) in the ICM group ( $P = 0.0001$ ), coronary artery bypass grafting in three (10%) in the DCM, and in 78 patients (86%) in the ICM group ( $P < 0.00001$ ). The mean follow-up time was  $567 \pm 74$  days in the DCM and  $793 \pm 63$  days in the ICM group (ns). **Results:** Early mortality was 6.6% (8/121), and was equal for both groups. Improvement in NYHA class (DCM  $3.3 \pm 0.1$ – $1.8 \pm 0.16$ ; ICM from  $3.2 \pm 0.04$  to  $1.7 \pm 0.07$ ) were equal between groups after 1 year. Seventeen (15%) late deaths occurred during the follow-up period. There was no difference in the 2-year actuarial survival between groups (DCM/ICM 0.93/0.85). Risk factors for mitral reconstruction failure, defined as regurgitation  $\geq 2$  after 1 year, were preoperative NYHA IV in the DCM group ( $P = 0.03$ ), a preoperative posterior infarction ( $P = 0.025$ ), decreased left ventricular function ( $P = 0.043$ ), larger ring size ( $P = 0.026$ ) and preoperative renal failure ( $P = 0.05$ ) in the ICM group. Risk factors for death were larger ring size ( $P = 0.02$ ) and an increased LVEDD ( $P = 0.027$ ) in the DCM group and the postoperative use of IABP ( $P = 0.002$ ), renal failure ( $P = 0.001$ ), and a larger preoperative LVESD ( $P = 0.035$ ) in the ICM group. **Conclusion:** Mitral reconstruction with a posterior annuloplasty using a flexible ring is effective in patients with severely depressed left ventricle function and has an acceptable operative mortality. Mid-term results are superior to medical treatment alone and comparable to cardiac transplantation.

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**Keywords:** Mitral valve disease; Ischemic mitral regurgitation; Heart failure cardiomyopathy

### 1. Introduction

Mitral regurgitation in patients with cardiomyopathy and severe left ventricular dysfunction remains one of the most challenging problems in cardiac surgery. Volume overload secondary to mitral regurgitation further increases ventricular dilatation and vice versa the degree of mitral

regurgitation through subsequent annular dilatation. This results in a ‘vicious cycle’ ending in severe mitral regurgitation in the presence of severe left ventricular dysfunction [1].

In patients with end stage cardiomyopathy mitral regurgitation clearly has a negative impact on survival being as low as 30% after 1 year [2–4]. Once medical therapy has been maximized, cardiac transplantation may be the only option available to this group of patients. Given the limitations imposed on cardiac transplantation due to organ shortage, age, and its restricted applicability in patients with concomitant extra-cardiac diseases, mitral reconstruction may represent a valuable alternative for these patients.

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Historically, operative mortality was increased in patients with severe ventricular systolic dysfunction undergoing mitral reconstruction [5]. Due to improvements in surgical techniques, myocardial protection, anaesthetic management and postoperative intensive care treatment mitral valve reconstruction has become feasible even in patients with severe decreased left ventricular function, including those with the need for concomitant coronary artery revascularization, tricuspid valve repair or arrhythmia surgery for chronic atrial fibrillation [6,7].

The present study analyses the 6-year results of 121 patients with dilated or ischemic cardiomyopathy, and a preoperative left ventricular ejection fraction  $\leq 30\%$ , undergoing mitral valve reconstruction with a flexible posterior band.

## 2. Patient and methods

### 2.1. Study group and patient characteristics

Between January 1996 and July 2002, 121 patients with idiopathic cardiomyopathy (DCM) or ischemic cardiomyopathy (ICM) and mitral regurgitation (MR)  $\geq 2^\circ$  were referred for surgery. All patients had severe left ventricular systolic dysfunction defined as left ventricular ejection fraction (LVEF) being equal or less than 30% on echocardiography and angiography. Patient characteristics are summarized in Table 1.

The etiology of MR was based on preoperative echocardiographic and angiographic findings, presence of posterior wall infarction, operative findings and pathologic examination. All patients with ICM and MR had a history of previous myocardial infarction. Coronary artery bypass grafting had already been performed in 15/91 (16.5%) of these patients. All patients received maximal medical therapy for congestive heart failure, including digoxine, angiotensin converting enzyme inhibitors, diuretics, and beta blockers. Furthermore, all patients were hospitalized at least once prior to surgery due to congestive heart failure and/or unstable angina. The mean preoperative NYHA functional class for DCM patients was  $3.3 \pm 0.1$  and  $3.2 \pm 0.04$  (ns) for ICM patients.

In the DCM group, atrial fibrillation was diagnosed in 11/30 (36.6%) patients, 4/30 (13.4%) were permanently

paced, and 15/30 (50%) patients were in sinus rhythm. In the ICM group, 18/91 (20%) patients were in atrial fibrillation, 9/91 (10%) were permanently paced, and 64/91 (70%) patients were in sinus rhythm.

### 2.2. Follow up

All patients were examined in the outpatient department 1 year after surgery. A standard questionnaire was used to evaluate clinical symptoms. The following diagnostic procedures were performed: physical examination, electrocardiography, and transthoracic echocardiography (TTE). Follow-up was complete for 100% of DCM and 93% of ICM patients. Postoperative readmission for congestive heart failure and cause of death were documented. In July 2002 all patients were contacted again by telephone to evaluate if they are alive. This second follow-up was 100% complete for DCM patients and 98% for ICM patients. The mean follow-up time (July 2002) was  $567 \pm 74$  days for DCM and  $793 \pm 63$  days ICM patients (ns).

### 2.3. Echocardiography

Preoperative TTE was performed in all patients by the same observer. At 1-year follow-up 84% of surviving patients had TTE again in our laboratory whereas the TTE videos of 12% of patients were sent to us from external cardiologists for evaluation. Two-dimensional and Doppler transthoracic echocardiography was performed using a Hewlett–Packard Sonos 4500 or 5500 (Hewlett-Packard, Andover, MA, USA) machine. Standard parasternal and apical images were obtained and left ventricular function and mitral insufficiency were assessed visually. In 5/121 (4%) patients (all ICM patients) it was not possible to receive a TTE videotape after 1 year.

### 2.4. Surgical techniques

Median sternotomy was used for first procedures and right lateral thoracotomy in case of three reoperations. Standard normothermic cardiopulmonary bypass (CPB) techniques with ante- and retrograde cold blood cardioplegia was used in most patients. Hypothermic cardiopulmonary bypass without aortic cross-clamping was performed in five patients (all reoperation cases). In case of coronary artery bypass grafting, coronary anastomoses were performed first, followed by reconstruction of the mitral valve through a left atrial or transseptal approach. In all patients implantation of a flexible posterior ring (Carbo Medics Annuloflex; Baxter Cosgrove or SJM Tailor, USA) was used to repair the mitral valve. The mean ring size was  $27.7 \pm 1.3$  in DCM group, and  $28 \pm 1.9$  in ICM group (ns). Mitral valve repair techniques used in addition to posterior flexible ring annuloplasty were in accordance to the pathology of the mitral valve leaflet and included posterior leaflet quadrangular resection in three patients (prolapse due

Table 1  
Patient characteristics

Characteristics	DCM Group (n = 30)	ICM Group (n = 91)	P-value
Age	$67.5 \pm 1.2$	$66 \pm 0.8$	NS
Gender (male)	15	63	0.05
Hypertension (yes)	12	72	0.0003
Diabetes (yes)	7	27	NS
Renal Insufficiency (yes)	11	28	NS

to elongated infarcted papillary muscle) and chordal transfer in two patients. Concomitant tricuspid valve repair was performed in 14/30 (46.6%) patients in the DCM, and in 11/91 (12%) patients in the ICM group ( $P = 0.0001$ ). Concomitant CABG with one anastomosis was performed in 3/30 (10%) patients with DCM, and in 78/91 (86%) patients with ICM. Mean number of distal anastomosis was  $2.4 \pm 0.15$  per patient in the ICM group. The mean duration of cardiopulmonary bypass/aortic cross clamp time in DCM group was  $91 \pm 4.7$  min/ $51 \pm 3.6$  min and in ICM group it was  $126 \pm 4.7$  min/ $76.3 \pm 3.3$  min, respectively ( $P < 0.00001$ ). Other concomitant procedures were aortic valve replacement (DCM 5/30pts; ICM 4/91 pts), aneurysmectomy (ICM 10/91 pts) and biventricular pacemaker implantation (DCM 5/30 pts; ICM 1/91 pts) ( $P = 0.002$ ).

### 2.5. Statistical analysis

The pre-, intra- and postoperative parameters were entered in a database and analysed. All calculations were performed using a commercial available statistical package (SPSS 9.0 for windows). The distribution of continuous variables is expressed as mean  $\pm$  standard error and comparison was tested by two tailed *t*-test (Mann–Whitney test). Categorical variables were compared by Chi-square test and Fisher's Exact test as appropriate. Preoperative and intraoperative variables were analysed for their relationship with postoperative mortality and morbidity and comparison was made between the groups. Survival was calculated according to Kaplan–Meier analysis.

## 3. Results

### 3.1. Mortality

Eight of 121 (6.6%) patients died within 30 days after surgery. There were 2/30 (6.6%) deaths in the DCM and 6/91 (6.6%) in the ICM group (ns). Reason for death was low-cardiac output in all patients except in one who died from perioperative cerebrovascular infarction.

There were 17/113 (15%) deaths during the follow-up period, 5/28 (18%) in the DCM, and 12/85 (14%) in the ICM group. In all DCM patients, death during follow-up was entirely due to progression of myocardial failure. In ICM patients, three causes of death were due to non-cardiac diseases and unrelated to cardiac surgery. One patient died of progression of a carcinoma disease, one of gastrointestinal bleeding and one because of cerebrovascular infarction. Actuarial survival of DCM and ICM patients is depicted in Fig. 1.

Risk factors for early and late death for the DCM group were a larger annuloplasty ring ( $P = 0.021$ ) and a preoperative larger LVEDD ( $P = 0.027$ ) whereas for the ICM group risk factors were preoperative larger LVESD

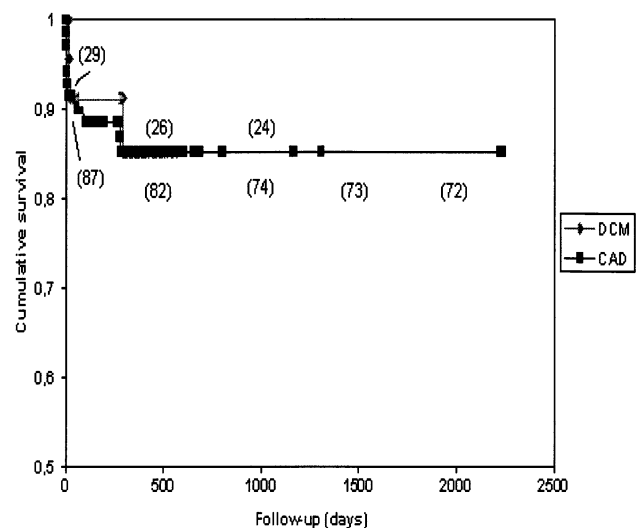


Fig. 1. Actuarial survival of patients with DCM and ICM. () number of pts. remaining at risk for main intervals analyzed.

( $P = 0.035$ ), preoperative renal insufficiency ( $P = 0.0014$ ) and postoperative use of IABP ( $P = 0.0022$ ).

### 3.2. Postoperative course

Inotrops to wean patients from cardiopulmonary bypass were used in 14/30 (47%) DCM and 47/91 (52%) ICM patients. In addition, intra-aortic balloon pumping was necessary in 7/91 (7.7%) ICM patients. The mean length of intensive care stay was  $3.0 \pm 0.4$  days in DCM group, and  $4.5 \pm 0.7$  days in ICM group, and the mean total length of hospital stay was  $13.7 \pm 6.5$  days in DCM group and  $12.4 \pm 6.2$  days in ICM group. Postoperative dialysis was necessary in 2/30 (6.7%) DCM patients and in 6/91 (6.6%) ICM patients. Pneumonia occurred in 10/91 (11%) and stroke in 4/91 (4.4%) ICM patients.

### 3.3. Follow-up

After one year NYHA functional class improved from  $3.3 \pm 0.1$  to  $1.8 \pm 0.2$  in the DCM, and from  $3.2 \pm 0.04$  to  $1.7 \pm 0.07$  in the ICM group ( $P < 0.001$  for both groups). Two/23 (8.6%) patients in the DCM, and 11/67 (16.4%) patients in the ICM group were in NYHA class III, but all these patients were in NYHA class IV prior to surgery.

Comparison of preoperative and follow-up echocardiographic and clinical data is shown in Table 2. There was a significant increase of left ventricular ejection fraction and decrease of left ventricular volumes in both DCM and ICM patients 1 year after operation.

Early reoperation for residual mitral regurgitation  $> 3$  was necessary in four patients (3.5%). In 1/30 (3.3%) patients with DCM and in 3/91 (3.3%) with ICM. In one ICM patient a second reconstruction with a smaller ring was carried out on the eighth postoperative day. The other

Table 2

Echocardiographic data preoperatively (PRE) and at 1-year follow-up (FU)

	DCM ( <i>n</i> = 30)			ICM ( <i>n</i> = 91)		
	PRE	FU	<i>P</i> -value	PRE	FU	<i>P</i> -value
NYHA-Class	3.3 ± 0.1	1.8 ± 0.2	0.0000	3.2 ± 0.04	1.7 ± 0.07	0.0000
LVEF (%)	23 ± 1.0	34 ± 2.7	0.0003	25 ± 0.5	32 ± 1.2	0.00001
LVEDS (mm)	53 ± 1.2	46 ± 2.4	0.03	50 ± 0.9	47 ± 1.2	0.04
LVEDD (mm)	65 ± 1.0	60 ± 1.7	0.02	64 ± 0.9	61 ± 1.0	0.1

LVEF, left ventricular ejection fraction; LVEDS, left ventricular endsystolic diameter; LVEDD, left ventricular enddiastolic diameter.

patients received a mitral valve replacement 2, 14 and 95 days after primary surgery.

After 1 year mean postoperative mitral regurgitation was grade 0.6 in the DCM and grade 1.0 in the ICM group. One patient in the DCM group (4%) and five patients in the ICM group (7%) showed mitral insufficiency grade 3. The risk factors for mitral insufficiency  $\geq 2$  were preoperative NYHA-class IV ( $P = 0.3$ ) and larger annuloplasty ring size ( $P = 0.02$ ) in patients with DCM. The presence of posterior infarction ( $P = 0.025$ ), lower preoperative ejection fraction ( $P = 0.043$ ) and larger ring size ( $P = 0.026$ ) were risk factors for mitral insufficiency  $\geq 2$  in patients with ICM.

#### 4. Discussion

Mitral regurgitation is a poor prognostic sign for patients with severe left ventricular dysfunction. Blondheim [3] studied 91 patients with dilated cardiomyopathy and demonstrated a significantly decreased 2-year survival in patients with mitral regurgitation compared to those with preserved mitral valve function. In addition, Anquita [8] was able to correlate long-term survival with left ventricular ejection fraction less than 30%, episodes of temporary cardiac decompensation, and increased left ventricular end-diastolic volume demonstrating limited survival and treatment options in this group of patients. Cardiac transplantation is one option for symptomatic and treatment-refractory patients with mitral regurgitation in the presence of severe left ventricular dysfunction, but it is hindered by donor organ shortage, and more important, through its limited applicability to older patients presenting with extracardiac co-morbidities. Finally, mitral valve replacement has not been routinely performed in this group of patients because of the presumed prohibitive operative mortality [9–11].

Studies by Hansen [12] and Saris et al. [13] using load-independent measurement of left ventricular contractility, demonstrate that division of all chordae tendineae was accompanied by a 47% reduction in maximal left ventricular elastance. Further, the effects of chordal detachment and reattachment on left ventricular function were assessed by load-independent measurements of maximal elastance. If all

chordae were detached, a significant decline of left ventricular contractility was seen, which was subsequently restored to baseline levels after the native chordae were reattached by repair of the papillary muscles. Thus, reconstruction of the mitral valve with preservation of annular–chordal–papillary muscle continuity [14] results in maintenance of LV systolic function, lower LV volumes, and less end-systolic wall stress [15,16] and has a lower mortality than mitral valve replacement [17]. Bolling [1] hypothesised that correction of mitral regurgitation through valve repair may stabilise or improve cardiac pump function by eliminating mitral regurgitation while preserving the mitral annulus–chordae–papillary continuity shown to be necessary for optimal left ventricular function and geometry.

In our patients, severe left ventricular dysfunction and mitral regurgitation would be predictive for a limited short-term survival. Nevertheless, mitral annuloplasty using a flexible posterior ring proved to be superior to results published with medical treatment alone as well as to those after cardiac transplantation. Besides improved mid-term survival, mitral valve reconstruction in these high-risk patients significantly increased functional capacity and decreased the incidence of repeated hospitalisation for treatment-refractory congestive heart failure.

Early mortality rate was 6.6% in our patients. Others published mortality rates of 9.2%, respectively 11% [18,19] in comparable patients. Actuarial survival after 5 years was around 70% for both DCM and ICM patients. Others have shown mid-term survival rates of 71% after 2 years [18], respectively 78% after 5 years [21]. Actuarial survival 5 years after heart transplantation is 68% as stated in the literature [22]. However, most of our patients were not candidates for heart transplantation due to age and/or concomitant diseases.

We found that a larger annuloplasty ring was a risk factor for overall mortality. Logically, these patients have a greater chance to develop recurrent mitral insufficiency and it is clear that prognosis of these patients decreases again. For this reason we agree with others that it is important to undersize annuloplasty rings [20]. In recent years we strictly follow this rule and we have the impression that frequency of recurrent mitral insufficiency is decreasing. This is especially true for patients with ICM. In these patients, downsizing of the mitral annulus as the only surgical step

restored leaflet coaptation eliminating mitral regurgitation presumably by acute remodelling of the base of the heart. This may re-establish an ellipsoid shape to the base of left ventricular cavity causing regression of left ventricular dimensions.

Larger preoperative left ventricular dimensions were also risk factors for overall mortality, maybe an indicator for impossibility of the ventricle to improve after correction of the mitral insufficiency.

It is striking how symptoms in terms of NYHA classification improved in both DCM patients and ICM patients. However, we recognised that not every patient had a profit from the operation. Unfortunately we could not find any factors that could predict NYHA-class improvement.

In most patients LVEF increased and left ventricular dimensions decreased significantly as shown by others [19, 1]. The mechanism of this phenomenon is yet not clear. Bolling [1] hypothesised the stabilization of the mitral annulus and LV unloading that has induced a more favourable ventricular geometry as a postulated mechanism for the improvement in ventricular function in patients with end-stage cardiomyopathy undergoing mitral valve reconstruction. However, coronary artery revascularisation in patients with ICM certainly helped at least in part to increase LVEF and decrease LVEDD and LVESD.

Four patients needed early reoperation of the mitral valve due to recurrent mitral insufficiency. The causes were a too large ring (32 mm) in one patient, a reoperation on postoperative day 8 and implantation of a smaller ring (26 mm) eliminated the problem and the mitral valve was competent at follow-up. The other reoperations because of recurrent mitral insufficiency were on postoperative day 2, 14 and 95 in one case because of chordal rupture after chordal shortening, in the other two cases the leaflets were altered and a second reconstruction was not possible. After 1 year echocardiography showed recurrent mitral insufficiency grade III in six patients. Interestingly, all these patients were satisfied with the result in terms of NYHA classification, and so a reoperation was not performed.

Increased preoperative left ventricular dimensions and severely decreased preoperative left ventricular ejection fraction were significant predictors for recurrent mitral regurgitation.

## 5. Study limitations

We are well aware of the fact that the etiologies of the two cardiomyopathy groups are different. In the ischemic group coronary bypass grafting and/or left ventricular aneurysmectomy combined with mitral valve reconstruction was carried out in most patients. In this group, postoperative improvement of left ventricular function can be either due to coronary revascularization or due to mitral valve reconstruction. However, since most of these patients had posterior myocardial infarction with necrotic myocardium

the benefit of revascularization is certainly not significant. An exact preoperative examination of viable myocardium of posterior wall would be the solution but is not feasible due to economical reasons.

In conclusion, mitral reconstruction with posterior flexible ring effectively corrected mitral regurgitation in patients with severely decreased left ventricular function due to dilated or ischemic cardiomyopathy. With regard to the increased surgical risk in patients with end-stage heart failure and the number of concomitant procedures, the operative mortality seems to be acceptable. Life quality improves after surgery due to a significant increase in exercise capacity. Mid-term results are encouraging and survival is superior to medical treatment alone and comparable to cardiac transplantation.

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## Appendix A. Conference discussion

**Dr R. De Simone** (Heidelberg, Germany): You report an acceptable mortality in this kind of procedure, but you didn't show us the data about patients without operation. You know that there is still controversy about treating these patients or not. Do you have some data of your own or from the literature?

**Dr Szalay:** It's very important to operate on these patients because the survival in these patients without operation is much worse compared to patients without operation.

**Dr De Simone:** But in order to make this statement, you have to compare, either with the literature or with your own data. If you leave the patients without the operation, how is the mortality?

**Dr Szalay:** Actuarial survival after 1 year in patients with a severe mitral insufficiency and NYHA-Class IV is about 30% without operation.